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Li et al.

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(54) **BURNER WITH A MODULAR FLAME RETENTION PLATE SYSTEM**

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(52) **U.S. Cl.** **431/266**; 431/187; 431/278; 431/284

(58) **Field of Search** 431/265, 266, 431/278, 8, 9, 12, 284, 353, 187, 188, 177, 354, 351, 350; 239/403–405, 505, 536, 520, 553, 554, 555, 561

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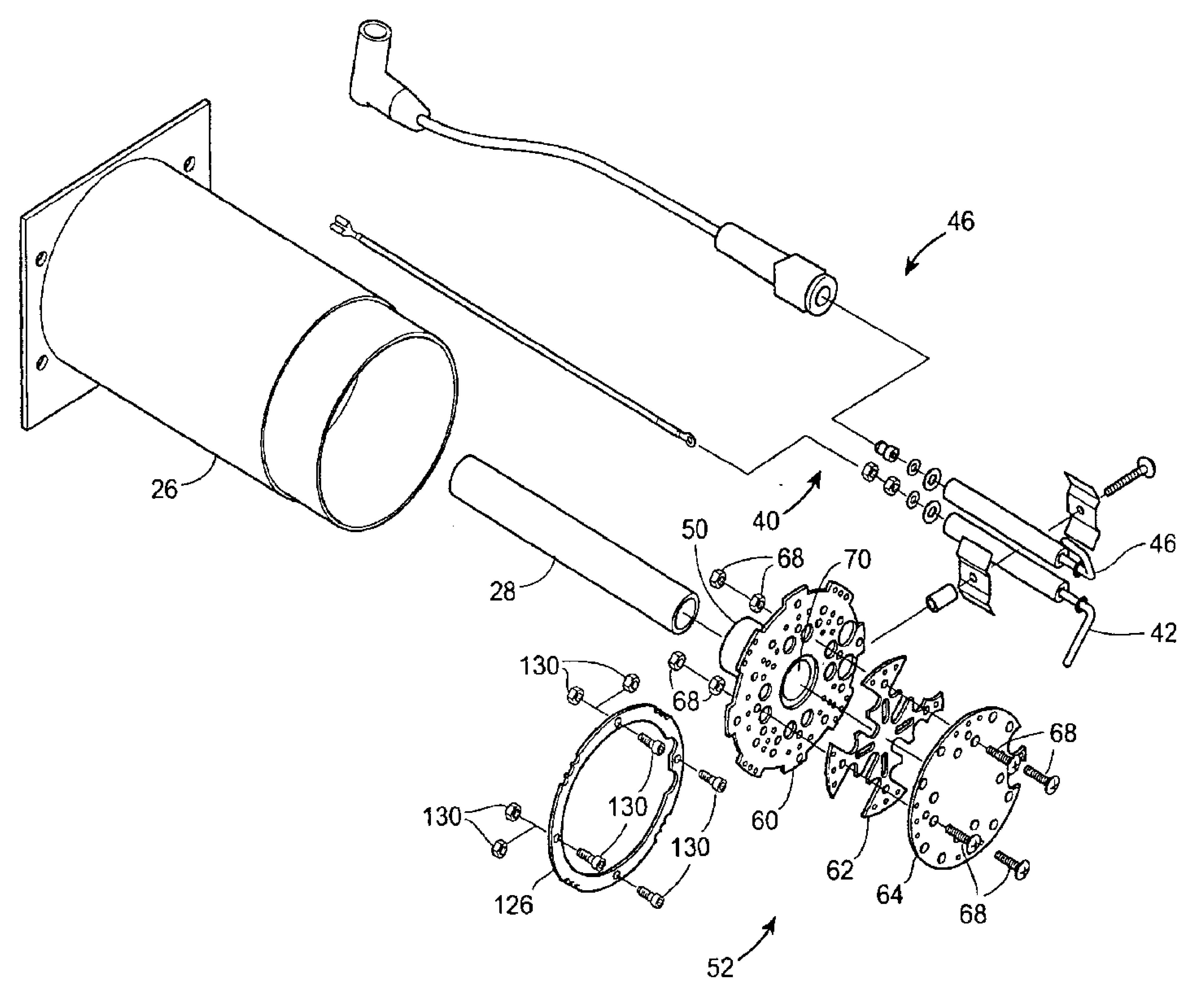
(57) **ABSTRACT**

A burner assembly includes a generally cylindrical burner tube having a combustion chamber. The burner tube supplies combustion air and combustion gas to the combustion chamber. A burner head assembly is disposed in the burner tube upstream of the combustion chamber. The burner head assembly includes a plurality of flame retention plates having a plurality of changeable flame retention plates removably mounted thereto. The flame retention plates include a base plate, at least one intermediate plate, and a top plate. Each of the base plate, the intermediate plate, and the top pate includes a plurality of combustion air flow and combustion gas flow apertures.

17 Claims, 11 Drawing Sheets



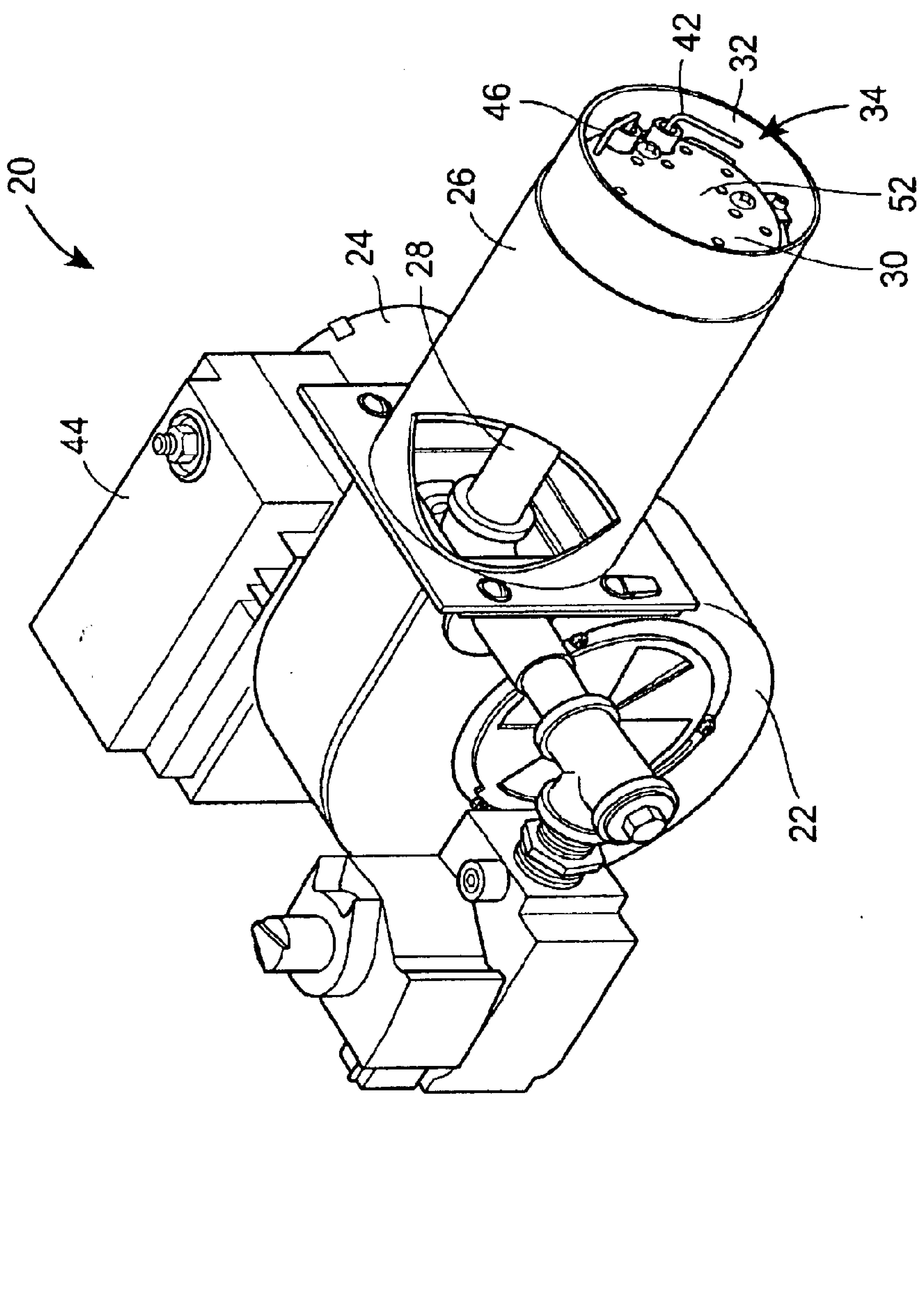


FIG. 1

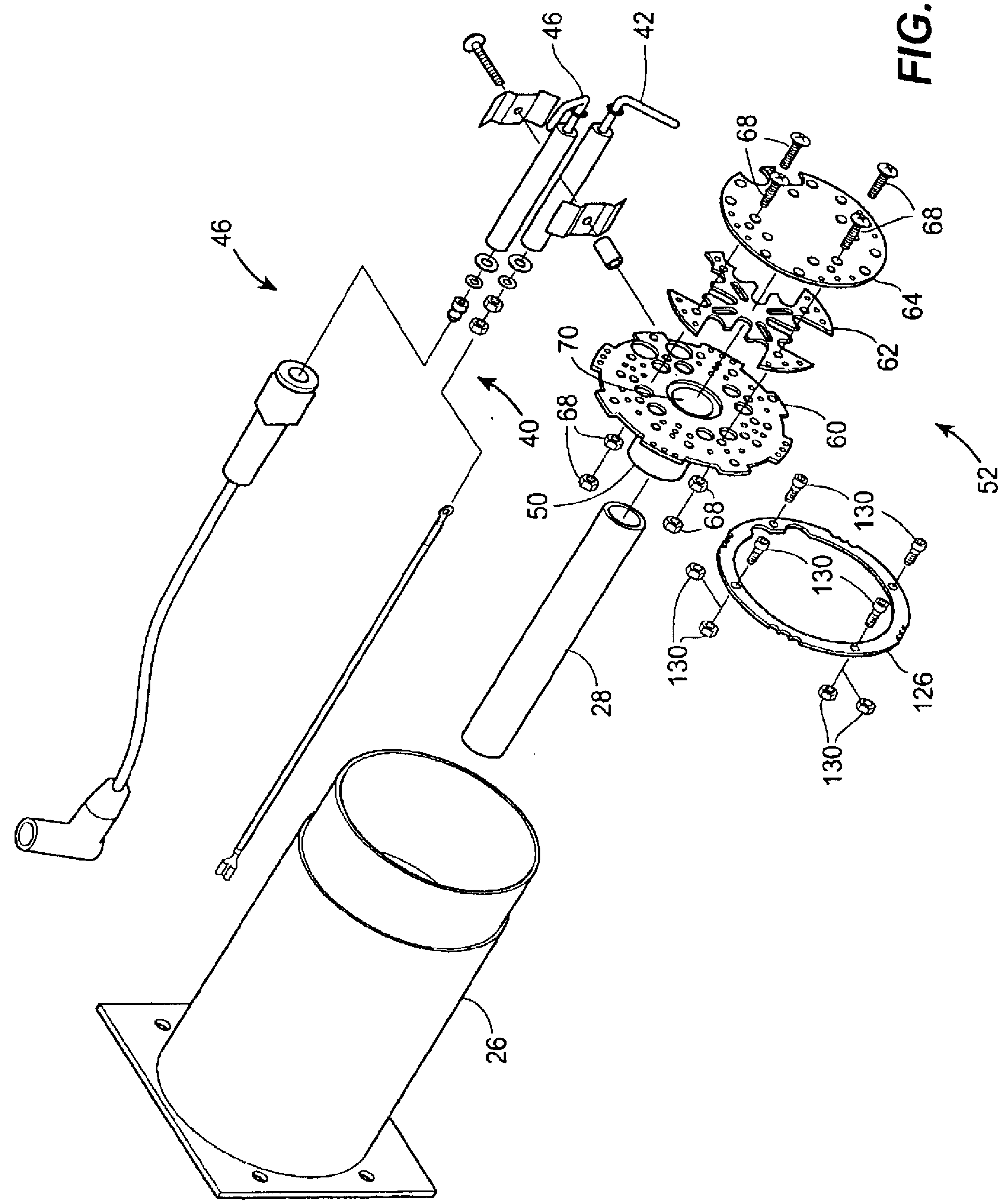

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FIG. 2

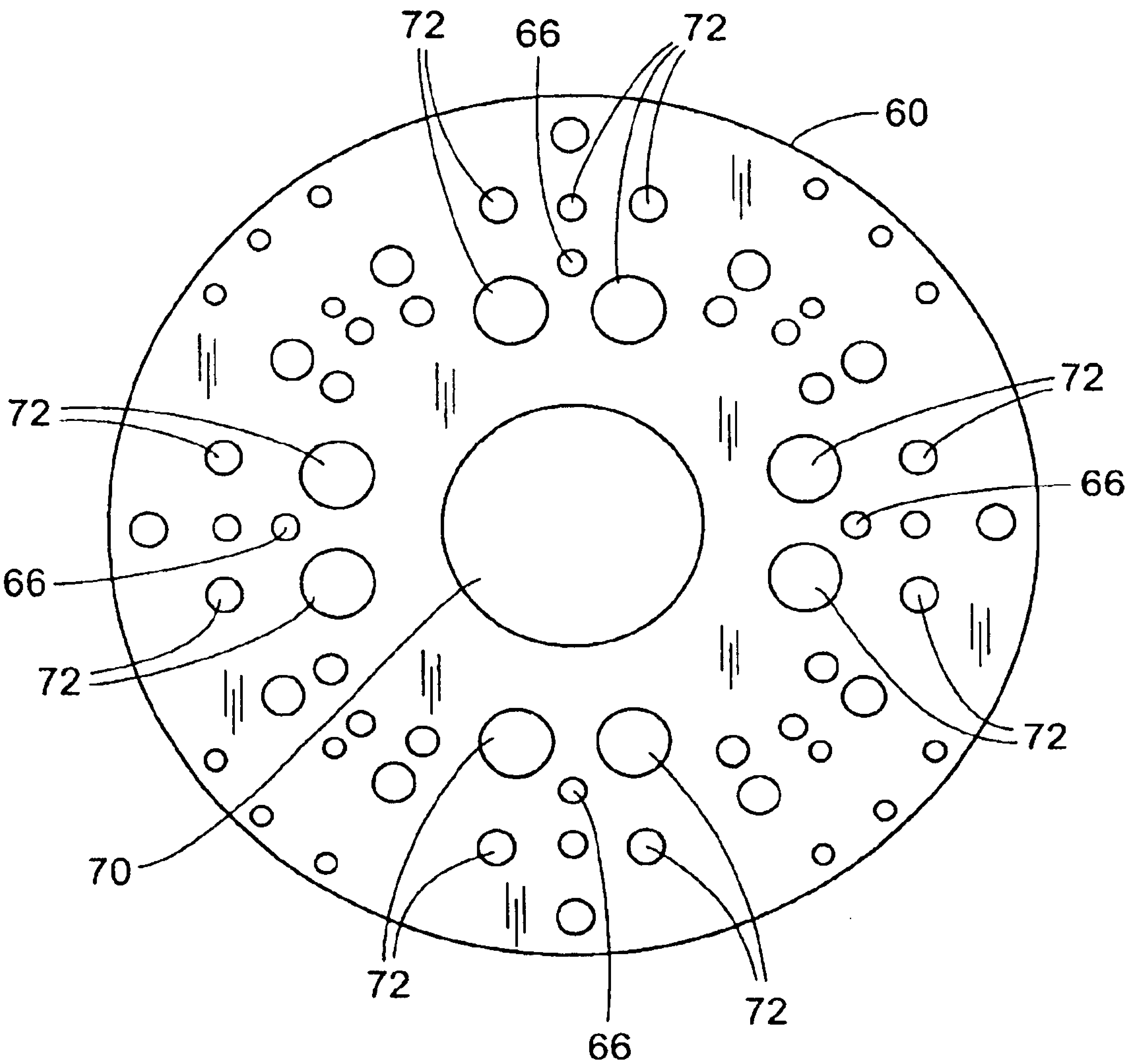


FIG. 3

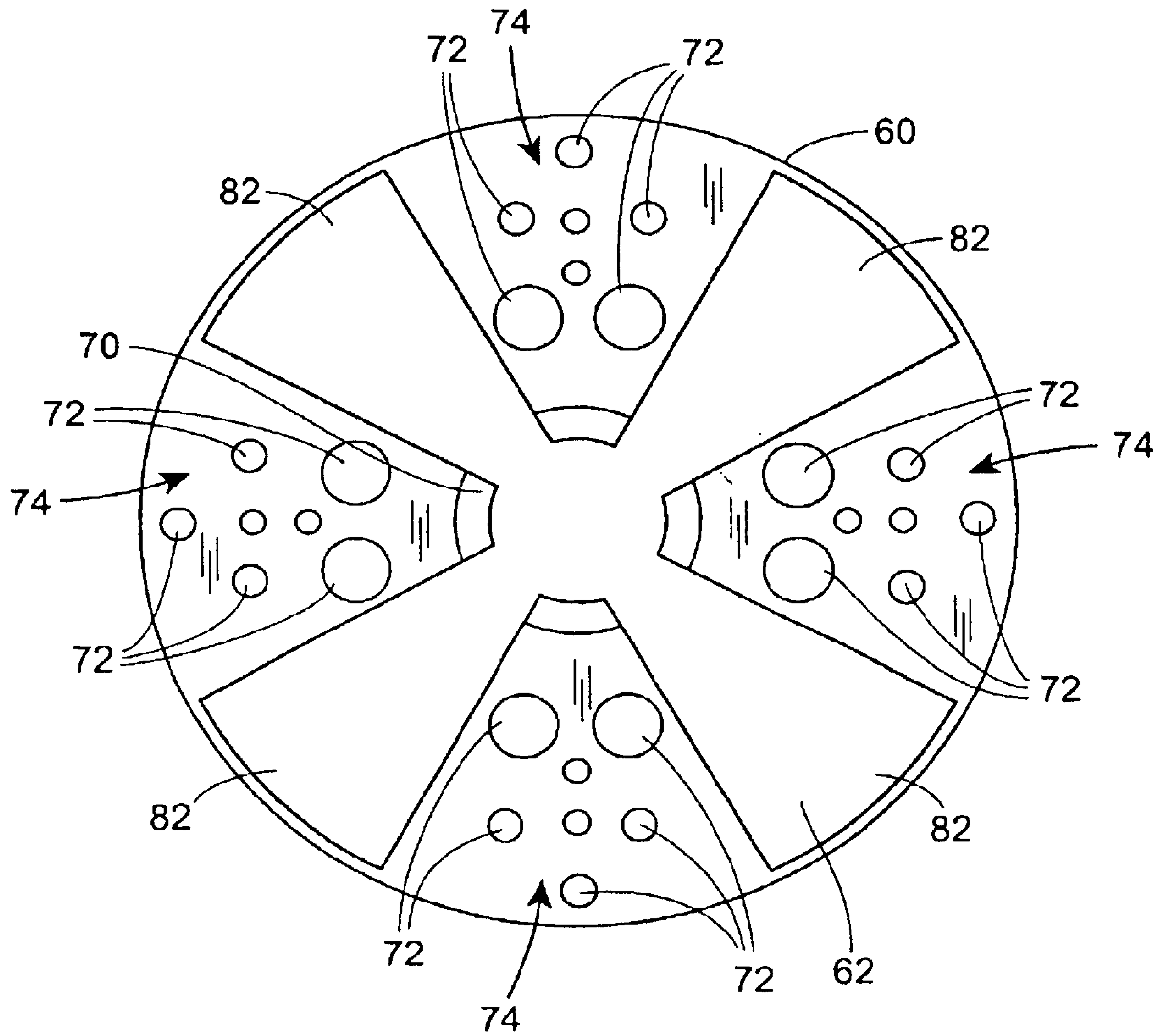


FIG. 4

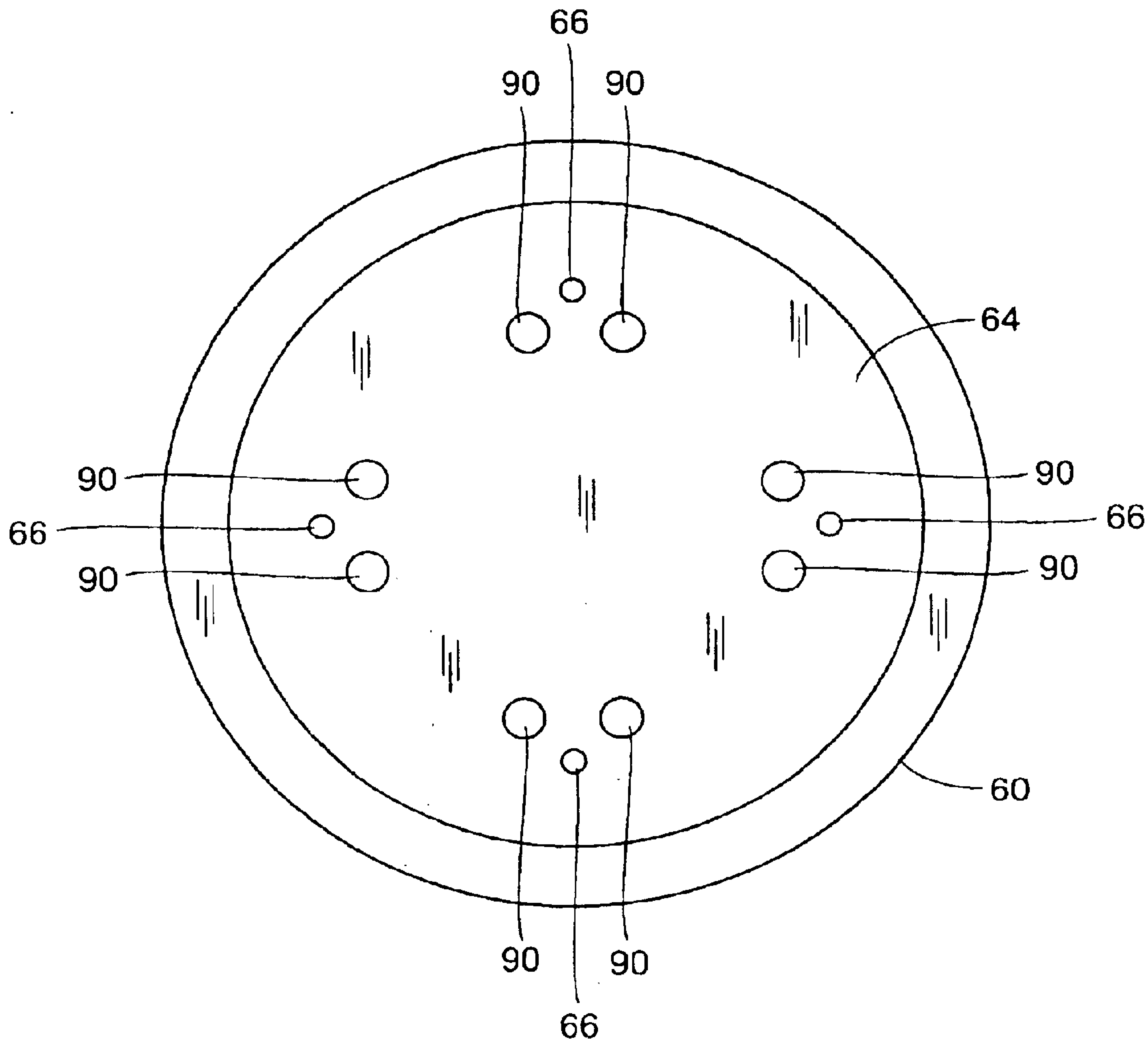
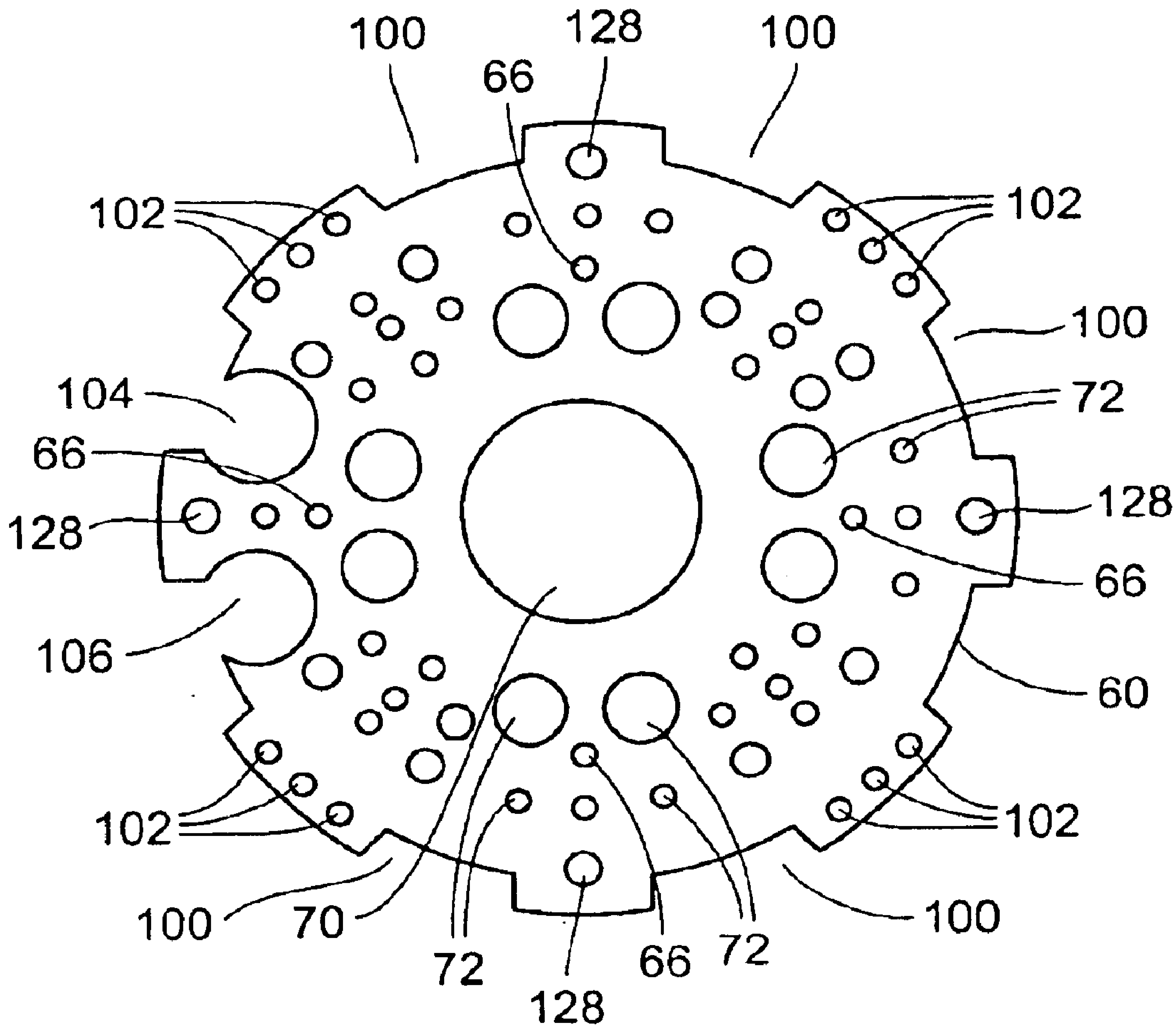


FIG. 5


100
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66
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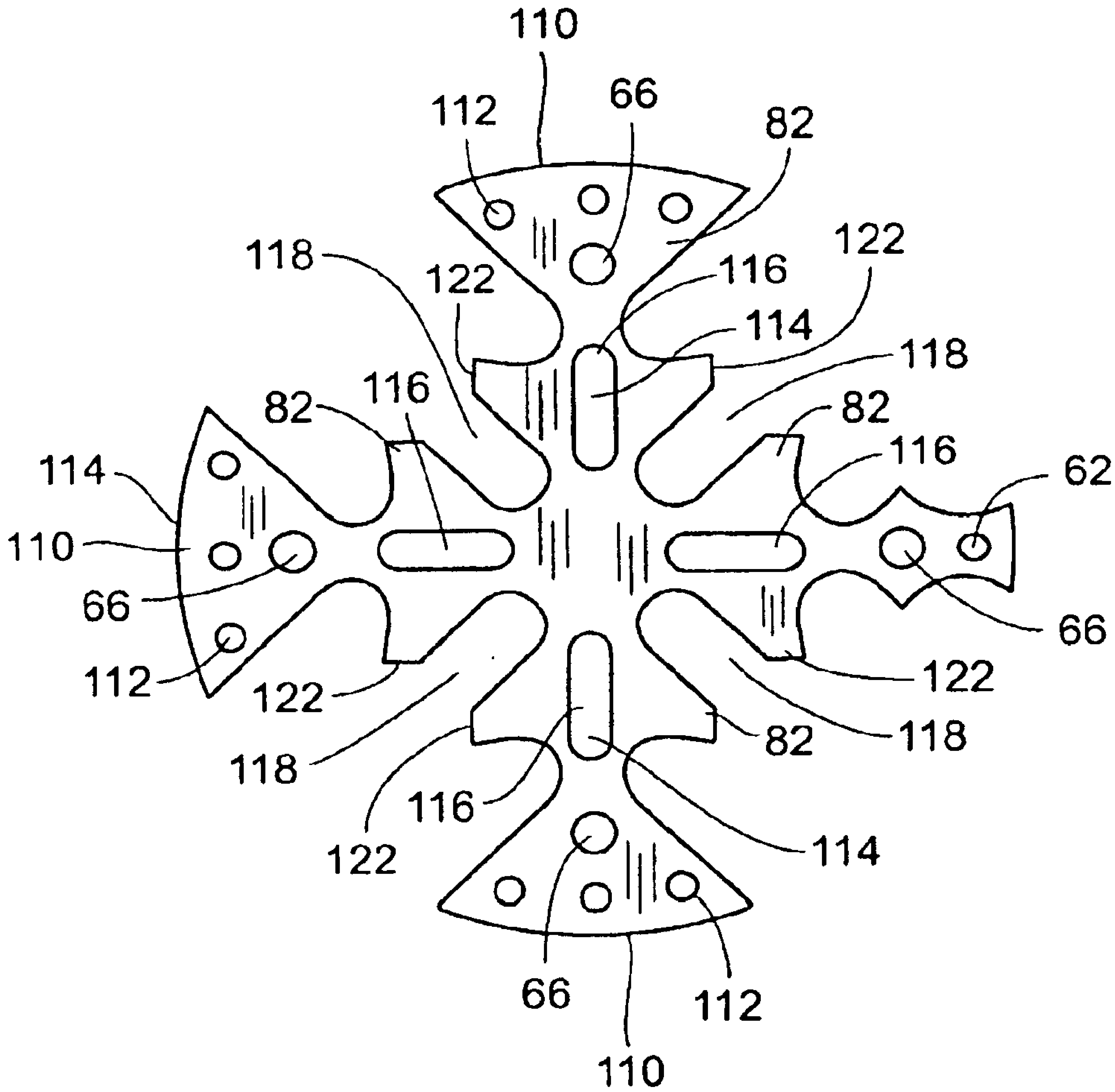
FIG. 6


110
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116
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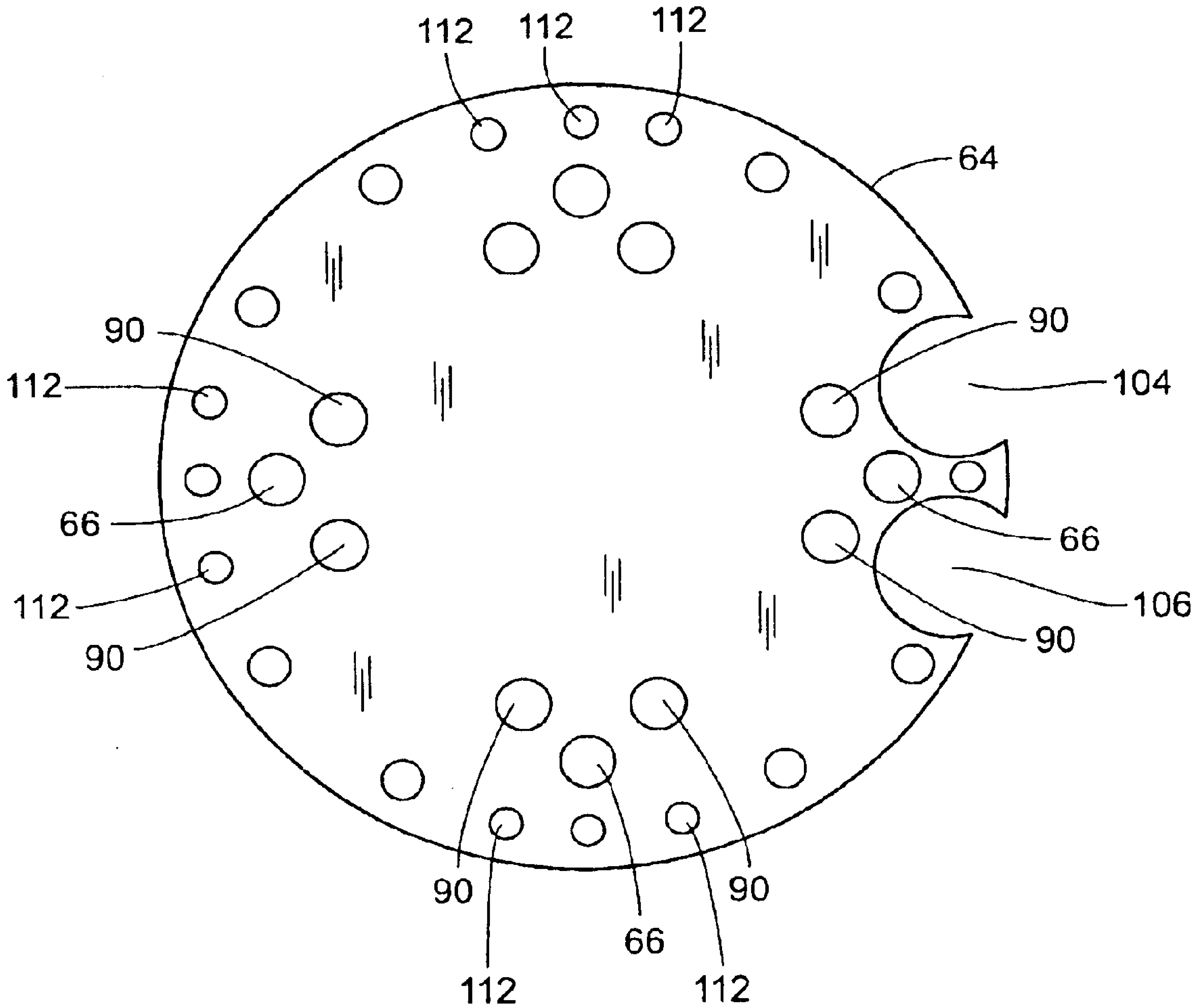
FIG. 7


112
112
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90
104
112
90
66
66
106
112
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90
66
112
112

FIG. 8

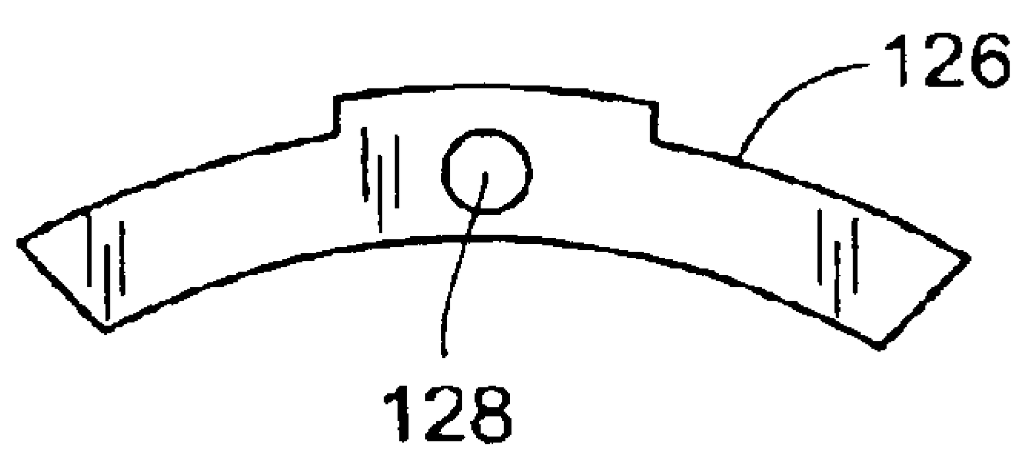
126
128

FIG. 9

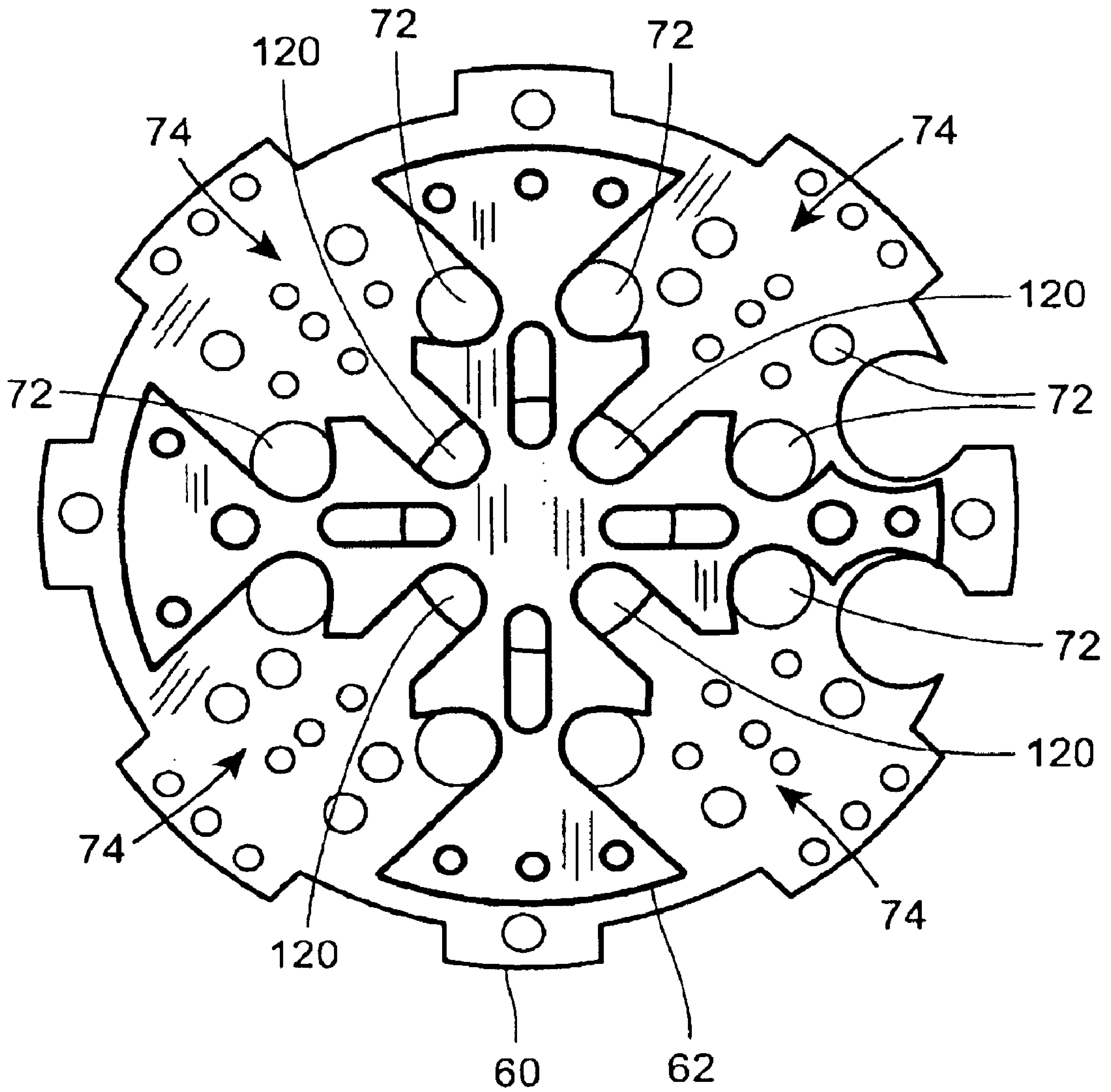

FIG. 10

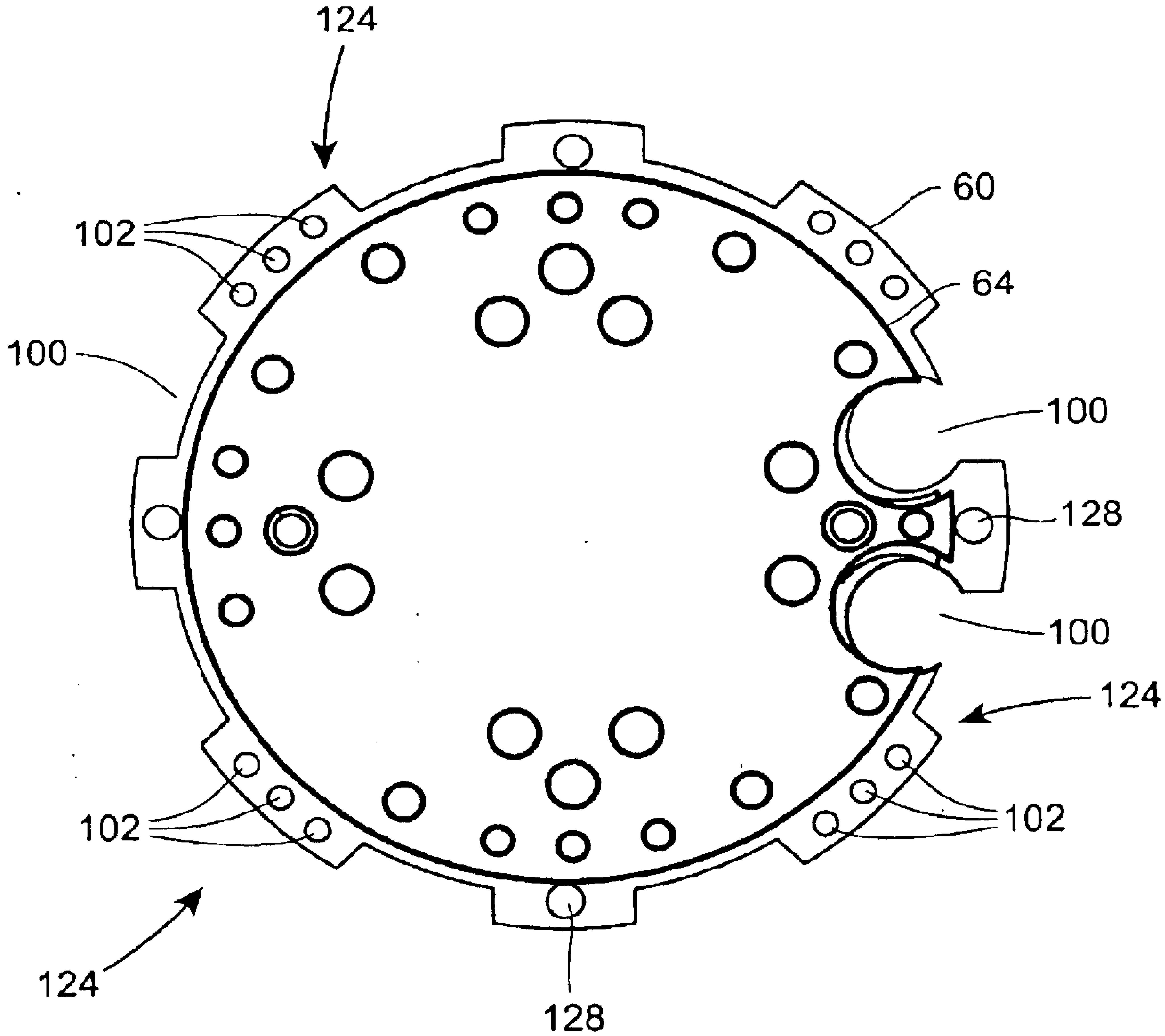

FIG. 11

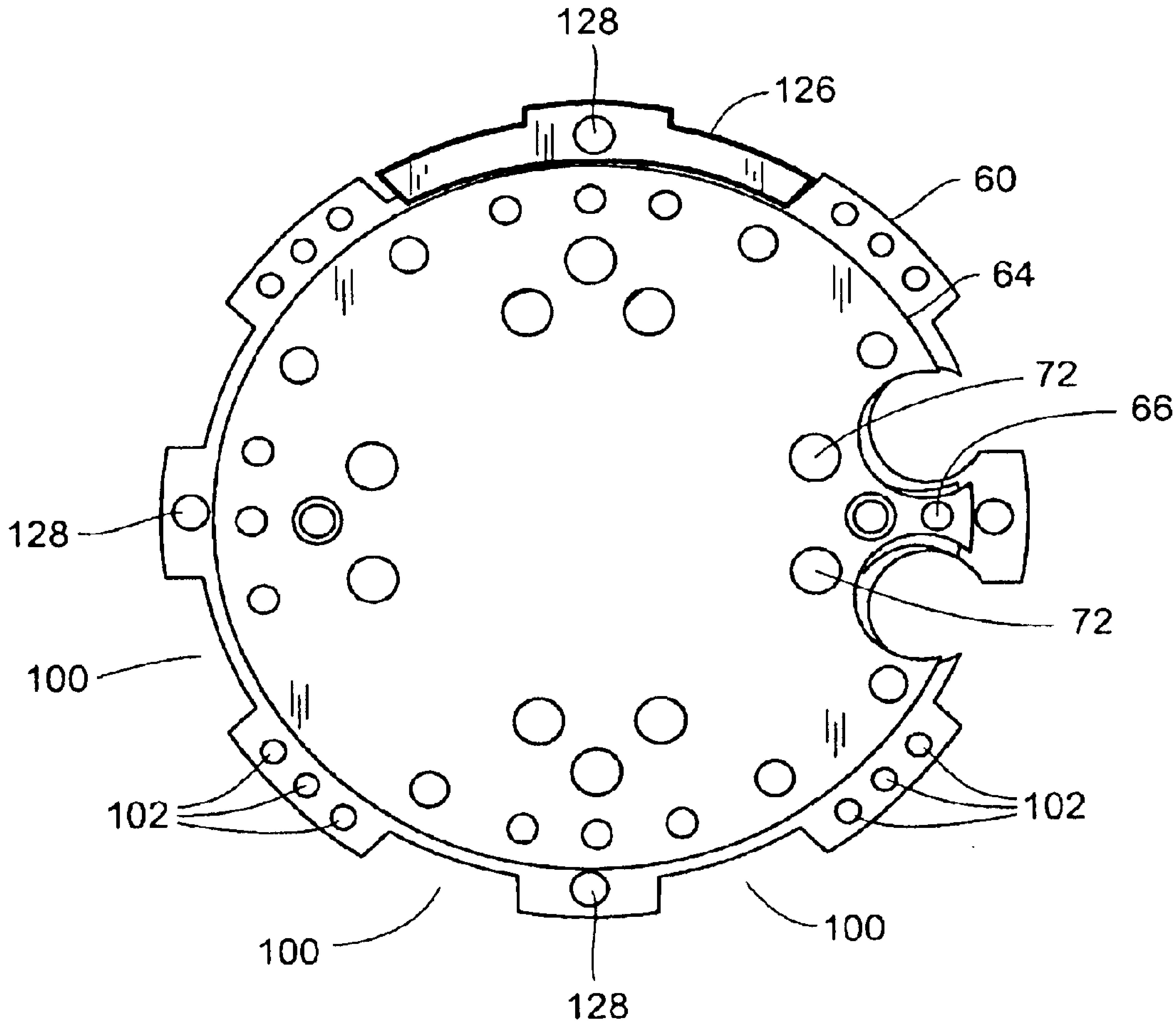

FIG. 12

BURNER WITH A MODULAR FLAME RETENTION PLATE SYSTEM

FIELD OF THE DISCLOSURE

The present disclosure generally relates to burners, and more particularly, to a burner with a modular flame retention plate system.

BACKGROUND

Burners which combust gas, such as propane and natural gas, are well known and widely applied. For example, boilers, furnaces, kilns, incinerators, dryers, and food processing equipment all commonly rely upon the heat generated by such combustion for proper operation.

Prior art burner designs have been created to mix a combustible gas with air and provide a spark for the purpose of starting. Extensive attention has been directed to finding proper mixing ratios and to creating apparatus for obtaining such ratios to most efficiently burn the gas while maximizing BTU output.

One known type of burner includes a substantially cylindrical housing provided with an inlet and an outlet. A motor connected to a blower or a fan wheel is typically connected to the inlet to direct air needed for combustion therethrough. A gas supply conduit typically enters the inlet end of the housing as well, and terminates in a gas nozzle short of the housing outlet end. The area of the housing downstream of the nozzle defines a combustion chamber. An ignition source, such as a spark plug or rod, is positioned proximate the gas nozzle and can be energized as needed.

In order to generate a desired airflow through the housing to the combustion chamber to obtain the desired BTU output and flame shape, various flame retention or nozzle plates have been created. Such plates are typically provided transverse to the longitudinal axis of the housing, and are positioned slightly upstream of the nozzle. The plates typically include various aperture designs to direct forced air therethrough. Additionally, the airflow velocity through the housing is typically controlled by a damper. Accordingly, the various aperture designs of the plates in combination with the control of airflow with the damper create desired characteristics in the resulting flame.

The airflow characteristics influence BTU output, flame stability, CO and NO_x emissions. BTU output is a measure of the strength of the flame and its resulting heat output, and is a function of, among other things, the amounts of air and gas combined and the ratio at which they are combined. Flame stability relates to the maintainability and controllability of the flame. If the gas/air ratio becomes too rich or too lean, the flame can be lost or can burn inefficiently. CO and NO_x emission control is critical in complying with various environmental regulations. If the flame is not suitably confined, shaped, and directed, all three of the foregoing characteristics will be adversely affected.

SUMMARY

A burner assembly includes a generally cylindrical burner tube having an end portion defining a combustion chamber. The burner tube supplies combustion air to the combustion chamber. A gas supply conduit disposed inside the burner tube supplies combustion gas to the combustion chamber. The burner assembly further includes a burner head assembly disposed in the burner tube upstream of the combustion chamber. The burner head assembly includes a plurality of name retention plates having a plurality of changeable flame retention plates removably mounted thereto.

A modular flame retention plate system for use in a burner with a combustion chamber includes a base plate disposed upstream of the combustion chamber, at least one intermediate plate mounted on and downstream of the base plate, and a top plate mounted on and downstream of the intermediate plate. Each of the base plate, the intermediate plate, and the top plate includes a plurality of combustion air flow and combustion gas flow apertures.

A method of controlling delivery of combustion air and combustion gas into a combustion chamber of a burner includes providing a plurality of interaction chambers upstream of the combustion chamber. Each interaction chamber is bound by a flame retention base plate, a flame retention intermediate plate, and a flame retention top plate. The intermediate plate is disposed between the base plate and the top plate. The shape of the interaction chamber is generally defined by the flame intermediate plate. The method further includes providing combustion air to each interaction chamber through a plurality of air flow apertures disposed in the base plate, and distributing combustion gas into each of the interaction chambers by a hub and a plurality of spokes of the intermediate plate. The spoke extend outward from the hub. The hub and the spokes receive combustion gas from at least one gas aperture disposed in the base plate. The method also includes delivering combustion air and combustion gas from each interaction chamber into the combustion chamber and through plurality of gas and air flow apertures disposed in the top plate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a burner with a modular flame retention plate system constructed in accordance with teachings of the present disclosure.

FIG. **2** is a perspective exploded view of a burner head assembly of the burner of FIG. **1**.

FIG. **3** is top view of an exemplary base plate of a modular flame retention plate system generally constructed in accordance with the teachings of the present disclosure.

FIG. **4** is a top view of an exemplary intermediate plate of a modular retention plate system generally constructed in accordance with the teachings of the present disclosure, shown mounted on the base plate of FIG. **3**.

FIG. **5** is a top view of an exemplary top plate of a modular retention plate system generally constructed in accordance with the teachings of the present disclosure, shown mounted on the intermediate plate of FIG. **4**.

FIG. **6** is a top view of a base plate of a first disclosed example of a modular flame retention plate system constructed in accordance with the teachings of the present disclosure.

FIG. **7** is a top view of an intermediate plate of a first disclosed example of a modular flame retention plate system constructed in accordance with the teachings of the present disclosure.

FIG. **8** is a top view of a top plate of a first disclosed example of a modular flame retention plate system constructed in accordance with the teachings of the present disclosure.

FIG. **9** is a top view of an arc shaped tab of a first disclosed example of a modular flame retention plate system constructed in accordance with the teachings of the present disclosure.

FIG. **10** is a top view of the intermediate plate of FIG. **7** mounted on the base plate of FIG. **6**.

FIG. **11** is a top view of the top plate of FIG. **8** mounted on the intermediate plate of FIG. **10**.

FIG. **12** is a top view of the arc shaped tab of FIG. **9** mounted on the modular flame retention plate system of FIG. **11**.

While the invention is susceptible to various modifications and alternative constructions, certain illustrative embodiments thereof have been shown in the drawings and will be described below in detail. It should be understood, however, that there is no intention to limit the invention to the specific forms disclosed, but on the contrary, the intention is to cover all modifications, alternative constructions, and equivalents falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION

Referring now to the drawings and with specific reference to FIG. **1**, a burner assembly having a modular flame retention plate system constructed in accordance with the teachings of the present disclosure is generally depicted by reference numeral **20**. The burner **20** includes a blower housing **22** in which a blower fan (not shown) is adapted to rotate. The fan is powered by a motor **24**. An air flow created by the blower fan is directed through a burner tube **26**, which is shown to be substantially cylindrical in shape. A gas supply conduit **28** that is concentrically housed in the burner tube **26** supplies combustible gas to a burner head assembly **30**, which is also disposed in the burner tube **26**. The burner head assembly **30** is attached to the gas supply conduit **28** and is disposed near an outlet **32** of the burner tube **26**. Accordingly, combustion gases are delivered to the burner head assembly **30** by the gas supply conduit **28**, while combustion air is delivered to the burner head assembly **30** by burner tube **26**. The burner **20** is primarily directed to combustion of propane, but is to be understood that other gases, including but not limited to natural gas, can be employed.

A combustion chamber **34** is defined by the space downstream of the outlet **32**. Air and gas are mixed and ignited in the combustion chamber **34** as will be discussed in further detail herein. The resulting flame (not shown) is directed outwardly through the outlet **32** of the burner tube **26**. The outlet **32** can be positioned proximate any suitable receiving conduit, heat exchanger, or chamber such as that provided in a boiler, furnace, heat exchanger, kiln or the like, to perform useful work therein.

A flame rod assembly **40** is positioned downstream of the plate system **52** to detect and ensure the presence of a flame. Such flame rod assemblies **40** are conventional and may operate by providing a flame rod **42**, which upon being heated by the flame, directs a suitable signal to a controller **44** of the burner **20**. The controller **44** may be in communication with a higher level integrated control system (not shown), which may take advantage of the signal to provide an indication to an operator as to whether a flame is present.

An ignition spark rod assembly **46** is also provided in the combustion chamber **34**. The ignition spark rod assembly **46** provides initial ignition such that upon actuation of the motor **24**, and flow of gas through the gas supply conduit **28** and the burner head assembly **30**, overall ignition of the burner **20** is insured. Ignition and continuous operation of the burner **20** are verified by the flame rod **42** and the controller **44**.

Turning now to FIG. **2**, the burner head assembly **30** includes a gas supply port **50** and a modular flame retention plate system **52** ("plate system **52**"). The gas supply port **50** is generally tubular and is attached to the gas supply conduit **28**, as by threaded attachment or the like. The gas supply port **50** receives combustion gas from the gas supply conduit **28** and delivers the combustion gas to the retention plate system **52**. The attachment of the gas supply port **50** to the gas supply conduit **28** is sealed so as to prevent combustion gas from mixing with the combustion air upstream of the plate system **52**. The gas supply port **50** includes internal threading that engages corresponding threads on the exterior of the gas supply conduit **28**. Thus, the burner head assembly **30** can be securely screwed onto the gas supply conduit **28**. One of ordinary skill in the art will appreciate, however, other numerous well known methods by which the gas supply port **50** and the gas supply conduit **28** can be sealably attached together.

The retention plate system **52** is oriented transverse to the longitudinal axis (not shown) of the burner tube **26**. Referring now to FIGS. **2–5**, an exemplary retention plate system **52** will be shown and described to include a base plate **60**, at least one intermediate plate **62**, and a top plate **64**, both of which are mounted on the base plate **60**. It is to be understood that the specific base plate **60**, intermediate plate **62** and top plate **64** depicted in FIGS. **2–5** are by way of example only. A more detailed embodiment is described later herein with reference to FIGS. **6–12**.

The base plate **60**, the intermediate plate **62**, and the top plate **64** include a plurality of mounting apertures **66**, which can be aligned to receive fasteners **68** for secure mounting of the intermediate plate **62** and the top plate **64** to each other and to the base plate **60**. As will become apparent in the following, the plate system **52** can include more than one intermediate plate **62**, which may be necessary to attain certain desired burn characteristics. Accordingly, as many intermediate plates as desired can be mounted between the base plate **60** and the top plate **64** to achieve desired burn characteristics.

The plate system **52** provides controlled mixing of the combustion air and combustion gas prior to combustion. The plate system **52** further provides controlled delivery of combustion air, combustion gas, and a mixture thereof to the combustion chamber **34** to achieve desired combustion characteristics. Accordingly, the plate system **52** receives combustion air from the burner tube **26** and combustion gas from the gas supply port **50**, provides a controlled and desired mixing of the received gases, and controllably delivers combustion air, combustion gas, and/or a mixture thereof to the combustion chamber **34**.

Referring to FIG. **3**, the base plate **60** is generally circular and has a diameter that is slightly smaller than the internal cross sectional diameter of the burner tube **26**. Accordingly, when the gas supply port **50** is attached to the gas supply conduit **28**, the base plate **60** substantially occupies the cross section of the burner tube **26**. The base plate **60** is attached to the gas supply port **50** such that a center aperture **70** of the base plate **60** receives combustion gas from the gas supply port **50**. The base plate **60** also includes a plurality of air flow apertures **72** that allow the combustion air in the burner tube **26** to flow through the base plate **60**. One of ordinary skill in the art will readily appreciate that flow characteristics of the combustion air downstream of the base plate **60** depend on the number of the air flow apertures **72**, the size of each air flow aperture **72**, and the position of each or groups of the air flow apertures **72** on the base plate **60**. Accordingly, any desired combustion air flow downstream of the base plate **60** can be achieved.

Referring to FIG. **4**, the base plate **60** delivers combustion air to one or more interaction chambers **74** in the retention plate system **52**. Each interaction chamber **74** is defined by a volume bounded by the base plate **60**, the intermediate plate **62**, and the top plate **64**. Furthermore, because the intermediate plate **62** is disposed between the base plate **60** and the top plate **64**, it generally defines the shape of each interaction chamber **74**. The intermediate plate **62** can be shaped and sized to control the delivery of combustion gas to the interaction chambers **74** and control the mixing characteristics of the combustion air with the combustion gas in the interaction chambers **74**.

The intermediate plate **62** includes a center portion, which will be referred to in the following as the hub **80**, and a plurality of spokes **82** that extend radially outward from the hub **80**. When the intermediate plate **62** is mounted on the base plate **60**, the hub **80** partially covers the center aperture **70** of the base plate **60**. Furthermore, each spoke **82** partially covers the center aperture **70** and extends radially outward from the hub **80**. The angular space between each pair of adjacent spokes **82** defines each of the interaction chambers **74**. The hub **80** provides controlled radial distribution of the combustion gas from the center aperture **70** of the base plate **60** to each interaction chamber **74**. The shape of each spoke **82** can affect the distribution characteristics of combustion gas in each interaction chamber **74**. Additionally, the shape of each spoke **82** can affect the mixing characteristics of combustion air and combustion gas in each interaction chamber **74**. Accordingly, each spoke **82** can include one or more slots, channels, and/or apertures (not shown) that receive combustion gas from the center aperture **70** and distribute the combustion gas to each interaction chamber **74** with a desired direction, angle, velocity, dispersion pattern, and pressure.

Referring to FIG. **5**, the top plate **64** includes apertures **90** that direct combustion air, combustion gas, and a mixture thereof to the combustion chamber **34**. Additionally, the size and shape of the apertures **90**, and the distribution of the apertures **90** on the top plate **64**, control the velocity, angle, direction, and/or the dispersion pattern of gases into the combustion chamber **34**.

The retention plate system **52** can direct combustion gas, combustion air, and/or a mixture thereof to any location in the combustion chamber **34** with any desired direction, angle, velocity, dispersion pattern, and pressure. To only provide combustion gas to the combustion chamber **34**, the hub **80** may include a number of apertures (not shown) that align with corresponding apertures (not shown) on the intermediate plate **62** and the top plate **64**. Accordingly, combustion gas can be directly provided to the combustion chamber **34** from the center aperture **70** of the base plate **60** through the intermediate plate **62** and the top plate **64**. To only provide combustion air to the combustion chamber **34**, each spoke **82** can include one or more apertures (not shown) that align with corresponding air flow apertures **72** of the base plate **60** and corresponding apertures on the top plate **64** to direct combustion air to the combustion chamber **34**. In effect, the combustion air is routed from the burner tube **26** directly to the combustion chamber **34** without being mixed with any combustion gas.

In some burners with high BTU output, the interaction chambers **74** may need to be larger than an interaction chamber provided by having only one intermediate plate **62**. Accordingly, in such burners, more than one intermediate plate **62** can be mounted between the base plate **62** and the top plate **64**. Furthermore, as one of ordinary skill in the art will readily appreciate, having more than one intermediate plate **62** provides the opportunity to place dissimilar intermediate plates **62** between the base plate **60** and the top plate **64**. Having dissimilar intermediate plates **62** in the plate system **52** provides a wide range of gas and air mixing and delivery thereof to the combustion chamber **34** that may not be possible with having only one intermediate plate **62**.

The sizes, locations, and group patterns of various apertures on the base plate **60**, the intermediate plate **62**, and the top plate **64** can affect the flow rate of combustion air, combustion gas, and a mixture thereof in the interaction chambers **74**. Furthermore, the sizes, locations, and patterns of various apertures relative to each other affect delivery of combustion air and combustion gas to the combustion chamber **34**. For example, misalignment of corresponding apertures when the intermediate plate **62** and the top plate **64** are mounted on the base plate **60** can affect the direction of flow out of the top plate apertures **90** and into the combustion chamber **34**. The sizes of the apertures relative to each other can affect the pressure and velocity of the flow in the combustion chamber **34**, while the size of corresponding apertures can further affect the shape of the flow in the combustion chamber **34**. For example, an aperture on the top plate **64** that corresponds and communicates with smaller apertures on the intermediate plate **62** and the base plate **60** may provide an expanding flow (i.e., the expansion affecting flow pressure) out of the apertures **90** of the top plate **64**. Similarly, an aperture on the top plate **64** that corresponds and communicates with larger apertures on the intermediate plate **62** and the base plate **60** may provide a contracting flow. One of ordinary skill in the art will appreciate from the foregoing that the sizes, locations, and group patterns of the various apertures on the plate system **52** can offer unlimited ways by which the flow characteristics upstream of and in the combustion chamber **34** can be controlled.

Referring to FIGS. **6**–**12**, an example of the disclosed plate system **52** is shown, where similar parts as those described in the foregoing have the same reference numbers. Referring to FIG. **6**, the base plate **60** includes the center aperture **70** and the plurality of air flow apertures **72**. The base plate **60** also includes a plurality of arc shaped air flow slots **100** distributed along its perimeter and a plurality of air flow apertures **102** disposed along its perimeter between each of the arc shaped air flow slots **100**. The base plate **60** further includes a flame sensing rod aperture **104** and an ignition spark rod aperture **106**. Each of the intermediate plate **62** and the top plate **64** also includes a flame sensing rod aperture **104** and the ignition spark rod aperture **106**, so that the flame sensing rod **42** and the ignition spark rod assembly **46** can pass through the retention plate system **52** into the combustion chamber **34**, as shown best in FIG. **1**.

Referring to FIGS. **7** and **10**, the intermediate plate **62** in the depicted embodiment includes four spokes **82** having enlarged end portions **110**, which include a plurality of air flow apertures **112**. Each spoke further includes a slot **114** that extends radially outward from the hub **80** and terminates at the enlarged portion **110**. Each slot **114** includes a slit **116** that is nearly transverse to the general direction of the slot **114**. Because the angular space between each pair of adjacent spokes **82** defines an interaction chamber **74**, in the disclosed example, the retention plate system **52** includes four interaction chambers **74**. Each spoke **82** has an outwardly flared shape as it extends radially from the hub **80**. Accordingly, each two adjacent spokes **80** define a radially extending hub aperture **118** for directing combustion gas from the center aperture **70** of the base plate **60** to a corresponding interaction chamber **74**.

Referring to FIGS. **8** and **11**, the flow apertures **90** of the top plate **64** are distributed more near the perimeter of the top plate **64** than near its center. Accordingly, when the top plate **64** is mounted on the intermediate plate **62**, the flow apertures **90** of the top plate **64** only communicate with the interaction chambers **74**.

Referring to FIG. **11**, the intermediate plate **62** is shown to be mounted on the base plate **60**, and the top plate **64** is shown to be mounted on the intermediate plate **62**. To provide proper alignment of the base plate **60**, the intermediate plate **62**, and the top plate **64**, the mounting apertures **66** of all three plates are aligned as shown in such a way so that the flame rod apertures **104** and the ignition spark rod apertures **106** of the plates are also aligned. The plates are then secured together by fasteners **68** that are housed in the mounting apertures **66**.

Referring to FIG. **10**, when the intermediate plate **62** and the base plate **60** are properly aligned, the hub **80** and portions of the spokes **82** cover the center aperture **70** of the base plate **60**. Accordingly, combustion gas flowing through the center aperture **70** is blocked by the hub **80** and is only allowed passage through the slots **114** of the spokes **82** and the hub apertures **118**. However, with reference to FIG. **11**, because the top plate **64** covers the intermediate plate **62**, except for the enlarged portions **110** of the spokes **82** and the interaction chambers **74**, the flow of combustion gas is diverted from its original direction along the burner tube **26** to a radial direction relative to the center aperture **70**.

As shown in FIG. **10**, the combustion gas enters and flows through the slots **114** and the hub apertures **118** from the center aperture **70** of the base plate **60**. As shown by arrow **120**, each of the hub apertures **118** directs combustion gas from the center aperture **70** to a corresponding interaction chamber **74**. To widely distribute the combustion gas in the interaction chamber **74**, openings **122** of the radial hub apertures **118** are flared outward. Each slot **114** directs combustion gas to a corresponding interaction chamber **74** through a corresponding slit **116**. The interaction chamber **74** receives combustion air through the combustion air apertures **72** of the base plate **60**. Accordingly, the combustion gas that is delivered to the interaction chamber **74** by the slots **114** and the hub apertures **118** interacts with the combustion air from the air apertures **72** of the base plate **60**.

As shown in FIG. **11**, the intermediate plate **62** and the top plate **64** of the disclosed example are smaller than the base plate **60**. Accordingly, the intermediate plate **62** and the top plate **64** do not completely cover the base plate **60** when mounted thereon. Additionally, each of the interaction chambers **74** opens over a perimeter region **124** of the base plate **60**, thus causing some of the mixed gases (i.e., combustion air and combustion gas mixture) from each interaction chamber **74** to flow to the corresponding perimeter region **124**. The mixed gases interact with combustion air flowing through the base plate **60** from the arc shaped slots **100** and the air flow apertures **102**, and flow downstream into the combustion chamber **34**.

The arc shaped slots **100** and air flow apertures **102** can vary in number, size, and distribution pattern so as to provide a desired air flow characteristic. One function of the air flow apertures **102** is to stabilize the flame that forms in the combustion chamber **34**. One of ordinary skill in the art will appreciate that such flame stabilization is directly related to the noise generated by the burning process.

In certain burner applications, it may be necessary to reduce BTU output of the burner by reducing the combustion air flowing into the combustion chamber **34**. To reduce the air flowing into the combustion chamber **34**, the plate system **52** of the disclosed example also includes a number of optional arc shaped tabs **126** that can be attached to the perimeter portion **124** of the plate system **52**. Referring to FIG. **12**, one such tab **126** is shown attached to the plate system **52**. The tab **126** is shown to be blocking the air flow from two arc shaped slots **100** and a group of air flow apertures **102** that are between the two arc shaped slots **100**. The tab **128** includes a mounting aperture **128**, which can be aligned with a number of corresponding mounting apertures **128** on the perimeter portion **124** of the base plate **60** to receive fasteners **130** (shown in FIG. **2** only). However, one of ordinary skill in the art will appreciate that larger tabs **126** (not shown) can be provided that can block more or even all of the arc shaped slots **100** and the air flow apertures **102**. One such large tab **126**, which fully covers the arc shaped slots **100** and the air flow apertures **102** is shown in FIG. **2**. Additionally, more than one tab **126** can be mounted to the plate system **52** to cover non-contiguous perimeter portions of the plate system **52**. The tabs **126** can provide full burner efficiency in the entire operating range of the burner **20**, or if the burner **20** is operating at less than full capacity, by controlling the velocity of combustion air.

In operation, the apertures **90** of the top plate **64** deliver a mixture of combustion air and combustion gas from each interaction chamber **74** into the combustion chamber **34**. The ignition spark rod assembly **46** ignites the mixture and a primary flame is formed downstream of each aperture **90**. Additionally, the mixture of combustion gas and combustion air entering the combustion chamber **34** from the perimeter regions **124** are ignited by the primary flame to form a secondary flame and more contiguous flame that blankets the discrete flames generated by the apertures **90** of the top plate **64**.

One of ordinary skill in the art will appreciate from the foregoing that the plate system **52** provides controlled mixing of the combustion air and the combustion gas and a controlled delivery thereof to the combustion chamber **34**. Such controlled mixing and delivery can provide a wide range of BTU outputs for the burner **20**, and provide flame stabilization, which reduces burner noise. Furthermore, the plate system **52** is modular, and therefore, highly customizable for use in various types of burners. Additionally, the plate system **52** facilitates controlled mixing and delivery of the combustion air and the combustion gas in a very small cross section of the burner tube **26**. Accordingly, burners using the disclosed plate system **52** can have short burner tubes **26**, and therefore, can be used in applications where space accommodations for the burner are minimal.

Persons of ordinary skill in the art will appreciate that, although the teachings of the invention have been illustrated in connection with certain embodiments, there is no intent to limit the invention to such embodiments. On the contrary, the intention of this application is to cover all modifications and embodiments fairly falling within the scope of the teachings of the invention.

What is claimed is:

1. A burner assembly comprising:

a generally cylindrical burner tube adapted to supply combustion air to a combustion chamber downstream of the burner tube;

a gas supply conduit disposed in the burner tube adapted to supply combustion gas to the combustion chamber; and

a burner head assembly disposed in the burner tube upstream of the combustion chamber, the burner head assembly including a plurality of flame retention plates removably mounted thereto, wherein the flame retention plates include a base plate, a top plate, and at least one intermediate plate disposed between the base plate and the top plate, the intermediate plate including a center hub and a plurality of spokes extending from the hub, wherein each pair of adjacent spokes, the base plate, and the top plate define an interaction chamber.

2. The burner assembly of claim **1**, wherein the hub includes hub apertures communicating with the interaction chambers.

3. The burner assembly of claim **1**, wherein each interaction chamber communicates with the burner tube by a plurality of apertures in the base plate.

4. The burner assembly of claim **1**, wherein each interaction chamber communicates with the combustion chamber by a plurality of apertures in the top plate.

5. A modular flame retention plate system for use in a burner having a cylindrical burner tube, the modular plate retention plate system comprising:

a base plate disposed near an end portion of the burner tube and having a plurality of combustion air flow and combustion gas flow apertures;

at least one intermediate plate mounted on and downstream of the base plate and including a plurality of combustion air flow and combustion gas flow apertures; and

a top plate mounted on and downstream of the intermediate plate and including a plurality of combustion air flow and combustion gas flow apertures, wherein the intermediate plate includes a center hub and a plurality of spokes extending from the hub, wherein each pair of adjacent spokes, the base plate, and the top plate define an interaction chamber.

6. The modular flame retention plate system of claim **5**, wherein each spoke includes at least one slot having a slit connecting the slot to an adjacent interaction chamber.

7. The modular flame retention plate system of claim **5**, wherein each spoke includes an enlarged end portion having a plurality of apertures.

8. The modular flame retention plate system of claim **7**, wherein combustion air is delivered to a combustion chamber through the plurality of apertures disposed in the enlarged end portion of each spoke.

9. The modular flame retention plate system of claim **5**, the hub including hub apertures communicating with the interaction chambers.

10. The modular flame retention plate system of claim **5**, wherein the base plate includes a plurality of air flow apertures disposed about a perimeter thereof.

11. The modular flame retention plate system of claim **5**, further comprising a plurality of changeable tabs mountable on a perimeter of the base plate, the base plate including a plurality of air flow apertures disposed about the perimeter thereof.

12. A method of controlling delivery of combustion air and combustion gas into a combustion chamber of a burner, the method comprising:

providing a plurality of interaction chambers upstream of the combustion chamber, the interaction chambers being generally bound by a flame retention base plate, at least one flame retention intermediate plate, and a flame retention top plate, the at least one flame retention intermediate plate being disposed between the flame retention base plate and the flame retention top plate, the shape of each interaction chamber being generally defined by the at least one flame intermediate plate;

providing combustion air to each interaction chamber through a plurality of air flow apertures disposed in the base plate;

distributing combustion gas into each of the interaction chambers by a hub of the intermediate plate, and a plurality of spokes extending outward from the hub, the hub and the spokes receiving gas from at least one gas aperture disposed in the base plate; and

delivering combustion air and combustion gas from each interaction chamber into the combustion chamber and through plurality of gas and air flow apertures disposed in the top plate.

13. The method of claim **12**, wherein the distributing of combustion gas into each interaction chamber is at least through a hub aperture communicating between the gas aperture of the base plate and the interaction chambers.

14. The method of claim **12**, wherein the distributing of combustion gas into each interaction chamber is through a slot disposed in at least one of the spokes adjacent the interaction chamber, the slot communicating between the gas aperture of the base plate and the interaction chamber.

15. The method of claim **12**, the slot communicating with an adjacent interaction chamber by a slit connecting the slot to the interaction chamber.

16. The method of claim **12**, further comprising delivering combustion air into the combustion chamber through a plurality of apertures disposed in an enlarged end portion of each spoke.

17. The method of claim **12**, further comprising delivering combustion air into the combustion chamber through a plurality air flow apertures disposed about a perimeter of the base plate.

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